

Nevada Test Site, Engine Maintenance Assembly
and Dissassembly Facility (E-MAD) (EMAD)
Area 25, Jackass Flats
Mercury Vicinity
Nye County
Nevada

HAER No. NV-25

HAER
NEV
12-MERC.V,
1-

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
National Park Service
Department of the Interior
San Francisco, California

**HISTORIC AMERICAN ENGINEERING RECORD
NEVADA TEST SITE, ENGINE MAINTENANCE
ASSEMBLY AND DISASSEMBLY FACILITY
HAER NO. NV-25**

HAER
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12-MERC, V,
1-

Location: End of EMAD Road from H Road; Jackass Flats, Area 25, Nevada
Test Site, Mercury Vicinity, Nye County, Nevada

USGS Jackass Flats 7.5'
UTM Coordinates 11 562100 4073450

Dates of Construction: 1962 - 1965

Engineer: The Vitro Engineering Company, New York

Builder: The Catalytic Construction Company

Present Owner: Department of Energy, Nevada Operations Office
P.O. Box 98518, Las Vegas, NV 89193-8518

Present Occupant: Not occupied

Present Use: Vacant; no public access

Significance: The Engine Maintenance Assembly and Disassembly Facility is significant for its role in the U.S. space program. The facility was part of a project that envisioned a nuclear-propelled launch vehicle for orbit around Mars, fly-by missions to Mercury and Jupiter, and eventually, past Pluto and beyond our solar system. While the tests conducted did not result in a nuclear-powered mission, they were important in their far-reaching potential. The success of the project revealed that such missions were technically feasible. Termination of the project was in 1973.

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I. DESCRIPTION

The Engine Maintenance Assembly and Disassembly (E-MAD) facility was designed to provide for the assembly, disassembly, and post-operative inspection of nuclear reactors associated with the Rover project. The Rover project involved the testing of experimental nuclear rocket engines during the 1960s and early 1970s. The facility, consisting of 25 acres, is in southwestern Nevada within the confines of the Nevada Test Site (Figure 1). The setting is one of isolation, in a valley, Jackass Flats, toward the northern extent of the Mohave Desert (see Photograph 1). Surrounding vegetation consists mostly of creosote and sage brush and accompanied by other small plants. Elevation is 3,520 feet. The nearest natural water sources are springs in the surrounding mountains; water is supplied to the facility from wells in the immediate area.

The facility is composed of a main building, separated into Hot and Cold bays, smaller ancillary buildings, an asphalt parking lot, asphalt roads, a water tank, an electrical substation, material storage and staging areas, and an interior and exterior railroad system (Figure 2). A chain-link fence surrounds the facility, and entry to the site is through a guarded gate toward the northeast corner.

Ancillary buildings on the site include a guard shack at the entry gate, a train shed and a building for flammable storage north of the main building, and two brock houses near the southwest corner of the building. Portable trailers, one being a first aid station, are at the south end of the building. A water tower and electric substation are to the east. Large asphalt-paved areas are at the north and east sides of the main building, with designated vehicle parking areas on the east side and southeast corner. An asphalt-paved road encircles the building to the south. Equipment and materials storage and staging areas are north and south of the building just beyond the asphalt pavements, and a waste storage area is to the southwest. A decontamination pit is located on the railroad line into the Hot Bay.

II. ARCHITECTURAL AND ENGINEERING INFORMATION

The main E-MAD building is roughly L-shaped, with 75,000 square feet of floor space, enclosed in an irregular-shaped envelope of concrete, corrugated metal, and concrete block. Roofs are flat, vary in height, many are surrounded by guardrails, and most hold a variety of heating, ventilating, and air conditioning (HVAC) equipment. The tallest roof reaches a height of 80 feet. The building consists primarily of three main floors, with a partial basement, a small mezzanine between the first and second floors, and a small machinery room as the fourth floor (Figures 3-5).

Two major complexes of the building are the Hot and Cold bays. The Hot Bay complex is a linear progression of concrete-shielded areas occupying the western portion of the building. In the northwest corner is the main Hot Bay. The Hot Hold and Transfer Tunnel extends south from the Hot Bay, flanked first by the East and West Process Cells, and then, proceeding south, by twelve small Post-mortem Cells. The Cold Bay complex, occupying the eastern portion of the building, consists of the Cold Bay, a Receiving and Storage Area, and an Office area (formerly the Engine Receiving Room). Other designated areas in the building include the Cell Service Area, Master Control Room, TV Control Room, Mechanical Support Shops, Facility Support systems, such as mechanical and electrical rooms, and Ancillary Support areas, such as restrooms, locker rooms, and conference and training rooms. A railroad network extends throughout the ground floor in both the Hot and Cold bays. It allows for the movement of large equipment, such as the nuclear rocket engines, to be moved around within and in and out of the facility. The rail network also connects with the testing sites, whereby the nuclear engines were transported from the E-MAD facility, tested, and then returned for inspection.

Exterior

The exterior of the E-MAD building, irregular in both height and configuration, is a combination of painted corrugated steel, bare concrete, and painted concrete block. In general, walls requiring radiation shielding are concrete, while non-shielded walls are either corrugated steel or concrete block. Openings include a variety of shielded and unshielded loading doors and personnel access doors. There are no windows.

The north elevation (see Photograph 2), large and planar, consists of the northern wall of the Cold Bay at its eastern end, and that of the Hot Bay at its western end. Between the Hot and Cold bays are metal-clad masses of intermediate height. Loading doors dominate the facade - a rolling metal door at the Cold Bay and a massive, steel-lined concrete blast door at the Hot Bay (see Photograph 3). Stenciled on the exterior of the door to the Hot Bay are the words "Door #122-1 360 Tons." This door is 22 feet wide, 37 feet high, and 5 feet thick. Extending from the wall west of the door are telescoping concrete cubes, connected by huge bolted steel couplings to an assembly of large fans, compressors, and a tall metal chimney.

The eastern elevation consists of the almost blank, corrugated metal wall of the Cold Bay at its northern end, and the one-story concrete block walls of the Post-mortem cell addition to the south (see Photograph 4). The center of the elevation consists of various differently-sized corrugated metal masses, containing mechanical and electrical equipment rooms. Mechanical equipment is mounted on most of the flat roofs here.

The south elevation begins, at its east end, with the south face of the Cold Bay wing, accessed by large, air-locking loading doors. The center of the elevation, at the crux of the building's L shape, are the multi-volume mechanical rooms mentioned above. The west end of the elevation consists of the projecting, one-story concrete block-clad Post-mortem wing. A rolling metal door forms the primary access here. A 25-ton overhead crane is also at this entrance.

The western elevation consists of large, planar masses of corrugated steel and concrete block. Openings are limited to three personnel doors: one at the north end from an interior stair well, and two at the south end from interior corridors. The northern two-thirds of the elevation is comprised of large, simple masses, consisting of the exterior walls of the operating galleries surrounding the Hot Bay (see Photograph 5). The southern third of the elevation is broken up into smaller volumes of space. It is here that the building steps down and is set back for the Post-mortem Cells.

Hot Bay

The Hot Bay consists of a huge volume of concrete-bound calibrated space, filled with equipment for the remote handling of radioactive materials. It was here that the nuclear engine was disassembled into its principal components after tests. The bay measures 146 feet by 66 feet and is 77 feet high. The floor, walls, and ceiling are concrete. Walls are five to six feet thick and penetrated by evenly-spaced, lead glass viewing windows of equal thickness as the walls. The windows are yellow-tinted and filled with clear oil. Technicians were able to perform their tasks from behind these windows with the aid of manipulator arms mounted on the walls and extending into the bay. The ceiling of the bay is 32 inches thick. Mounted on the ceiling are industrial pendant lights. Large concrete blast doors occupy major portions of the north and south end walls. A shielded door airlock for entry into the Hot Bay by personnel is in the northeast corner. Standard gauge railroad tracks traverse north-south through the bay and into the Hot Hold and Transfer Tunnel. A large round turn-table occupies the south end of the room. It has identical capabilities as the one in the Cold Bay, with the capacity to handle a 100 ton static load and an 80 ton dynamic load. The entire floor of the bay is ringed by a one foot wide gutter, with drains at regular intervals. On the west side of the bay are 24 circular holes in the floor, approximately 18 inches in diameter, related to the spent fuel handling project. This particular area is outlined by a roughly six inch wide metal grate encircling the holes. On the east side of the Hot Bay, opposite the circular holes, is a shielded storage pit. It measures about 26 feet long, 4.5 feet wide, and 13 feet deep, and has a three-piece cover 5 feet thick. The pit is provided with cool air from the HVAC system.

Most of the equipment is mounted on the east and west walls, corresponding with the viewing windows (see Atomic Energy Commission 1966 for detailed descriptions of various equipment). Calibration marks, on all walls, consist of black cross-hairs, with a graduated number at each point. These marks aid in positioning the equipment, e.g., cranes and large manipulators, throughout the bay via overhead and wall-mounted tracks. Two large General Electric manipulators, termed Wall Mounted Handling Systems (WMHS), are mounted on the east wall (see Photograph 6). Horizontal tracks, spanning 134 feet, at the top and bottom of these mechanisms extend along the length of the wall. These manipulators could handle loads up to 600 pounds even with the arms fully extended to about 30 feet and covering approximately the east half of the Hot Bay. Pairs of smaller master-slave manipulators (see Photographs 7-12) are at each of the first floor viewing windows on the east wall. These manipulators are designed to mimic the natural movements and forces of the human hand and were used for the remote disassembly and examination of small engine parts. Three different load capacities are available, including 10 pounds for the standard duty, 30 pounds for standard duty and extended reach, and 100 pounds for heavy duty.

The rail cars standing within the space are the most dramatic elements of the remote handling system. The first is a heavily-shielded, manned control car used to transport the nuclear engine to and from the test stand. The other is a flatbed vehicle, with a steel frame mounted on it. This car, in tandem with the manned control car, is the engine "Emplacement/Installation Vehicle" that installs and removes the engine from the test stand. Currently, at one end of this vehicle, with its own attachment to the rails, is a steel tube used in the handling of canisters during the spent fuel project.

The last major piece of remote manipulating apparatus is the large overhead positioning system (OPS) capable of ranging the length and width of the bay. This equipment consists of a 47 foot long traveling bridge, a telescoping mast with a 40 foot extension, and an auxiliary manipulator with an extension or retraction capacity of 11 feet. It has a load capacity of 20 tons. The mast appears as a steel framed box, fitted with a round-headed fixture at its bottom, providing azimuth rotation, leveling, and load readout. The OPS was remotely controlled by portable controlling units that plugged into control stations at the viewing windows. It was used for the remote disassembly of nuclear engines and for placing the engine or one of its components onto receiving stands.

Crane Maintenance Balcony

A service balcony is located at the south end of the Hot Bay, at the third floor level, over the Hot Hold and Transfer Tunnel and the processing cells. The balcony was used as a maintenance area for the crane, overhead positioning system, manipulators, and other support equipment in the Hot Bay. Stools, workbenches, and tools still occupy the space. A

shielded door air lock accesses the area from a third floor changing room. Rolling concrete doors, now in the open position, provided shielding between the balcony and the Hot Bay. Small rooms on the third and fourth floors housed the mechanisms, including motors and chain pulleys, for operation of the shield door. Both of these rooms have exterior doors providing access to different exterior roofs.

Hot Hold and Transfer Tunnel (HHTT)

The Hot Hold and Transfer Tunnel is a concrete-shielding area connecting the Hot Bay to the Process and Post-mortem cells and primarily functions as a holding and transfer area for radioactive engine components. Immediately south of the Hot Bay and underneath the crane maintenance balcony, it can be isolated from the Hot Bay and the smaller cells by steel shield doors. The door from the Hot Bay is 18 feet wide and 29 feet high. Material or equipment can be moved into the HHTT by standard-gauge railroad tracks extending from the Hot Bay. The tunnel is also equipped with a turntable that allows the floor-mounted handling system carriage or dolly to be positioned for transfer into the Process or Post-mortem cells. The turntable is 15 feet in diameter and has a 75,000-pound static and dynamic load capacity. Visual observation into the HHTT is provided by a closed-circuit television system.

East and West Process Cells

These two concrete-shielded areas, the East and West Process cells, were designed for the disassembly of the reactor core into its basic components. They are encased by six foot thick walls, and are located just south of the Hot Bay at either side of the HHTT. Steel shielding doors separate these two areas from the HHTT. They are of identical dimension, measuring 46 feet by 28 feet, and 29 feet high. The West Process Cell had four shielded viewing windows, one of which is now infilled with electrical equipment. These windows presumably all were equipped with master-slave manipulator arms; currently, only one window has an intact set. Other equipment within the space includes a PaR Model 3000 bridge-mounted rectilinear manipulator, a 15-ton overhead bridge crane, and a floor-mounted handling system carriage and dolly for transferring material between the HHTT and the West Process Cell. The East Process Cell was never activated for engine disassembly, and consequently, viewing windows, handling equipment, and special lighting were not installed. Instead, it was used for manual maintenance of remote handling equipment.

Cell Service Area (CSA)

This rectangular space connects the HHTT with the rail-accessed south airlock entrance. It is also one of the handling areas in the hot cell complex whereby irradiated materials could be moved directly into the Post-mortem Cells. The remote handling of irradiated materials

is provided by an overhead 7-1/2 ton crane and a bridge-mounted rectilinear manipulator. A steel shield door at the south end of the space leads to an airlock, beyond which is an exterior truck loading station. This station at the south end of the building is serviced by an overhead monorail crane with a capacity of 25 tons.

Post-mortem Cells

These twelve small hot cells are located on either side of the Cell Service Area (see Photographs 13-15). Four of the cells, two on each side, are 16 feet by 9 feet 7 inches and 15 feet high, while the remaining eight cells, four on each side, are 8 feet by 9 feet 7 inches and 15 feet high. Each cell has a shielded viewing window with master-slave manipulators. All of these are currently intact. Each cell was also provided with a 72 inches long by 70 inches wide and 16 inches high flat car for moving material between the cell and the Cell Service Area. One of these cars remains in the transfer tunnel. Equipment in these cells could perform a variety of physical, electrical, metallurgical, and radiological tests, and ninety percent of the remote laboratory work was performed here.

Operating Galleries

Operating Galleries are along the east, south, and west sides of the Hot Bay complex on the first, second, and third floors (see Photograph 16). The galleries have vinyl tile flooring, concrete walls along the hot cells, steel panel or concrete block walls at the perimeter walls, and concrete or steel ceilings. They serve as circulation, both air and traffic, and provide for office spaces and control stations (see Photograph 17). Control stations for the remote viewing and operation of the remote handling manipulators are present for both the Hot Bay and Post-mortem Cells (see Photographs 18-19). Over forty of the smaller manipulator arms are found on the first and second floor galleries. A periscope for detailed viewing is usually located next to the smaller arms. Hoists for transferring equipment between the first and second floors are present in both the east and west galleries. Electric panels and monitoring gauges are mounted on the walls throughout the galleries.

Master Control Room (MCR)

The master control room, accessed from the second floor Operating Gallery, is located at the southwest corner of the Hot Bay and has a sweeping diagonal view into the bay through a shielding window. The space has raised floor sections for electronic equipment, concrete walls, and an acoustical tile ceiling. Functioning as the management control center for the facility, operating equipment includes banks of video, telecommunication controls, and remote handling controls. Equipment controlled from here includes the Hot Bay overhead crane, OPS, large manipulators, shield doors, swingout rails, transport cars, and floor

turntables. Communication and visual systems controlled includes the headset intercom net, the closed-circuit television monitors, radio nets connecting the MCR with other NTS facilities, mobile support vehicles, and the Railroad Transport system. The MCR was also the coordination center for railroad movements, including track switching, at E-MAD and other associated facilities in Area 25.

Cold Bay

The Cold Bay, used for receipt and assembly of nuclear rocket engines, minus the reactor core, is located at the northeast corner of the building. The Cold Bay is 140 feet long, 72 feet wide, and 60 feet high, and is served by an overhead 40-ton crane having a 10-ton auxiliary hook with a clear lift of 45 feet. The crane spans the space in an east-west direction, running in tracks mounted on the north and south walls. The north and east walls and the upper portion of the west wall are metal. One bay of each wall features lateral force-resisting X-bracing. The south wall and the lower portion of the west wall are concrete block. The ceiling is corrugated metal, supported on steel trusses. The floor of the bay is concrete with a 34 foot diameter turntable, and has embedded standard gauge railroad tracks. Two train engines, one large and one small, are still present at the east end of the bay.

Loading doors are located on the north and south walls. A large, 45 foot high rolling metal door occupies the north wall. Directly opposite, connected by railroad tracks, are double casement-type steel doors. A second rolling metal door is at the east end of the south elevation. This has been fixed in a half-open position, the bottom infilled with a man-door opening to an office area. On the east wall, conduit runs have been installed such that a future loading door could be accommodated - they go up and around a non-existent door.

Receiving and Storage

Located south of the Cold Bay is the receiving and storage area, comprised of three rooms: the large, L-shaped "Materials, Storage, Tool Crib and Documents Room" connecting to the air lock entry, the smaller, square, "Bonded Material Storage Room" (locked and inaccessible at time of fieldwork), and the "Security Vault." The rooms have concrete floors, with railroad tracks running into the main space from the Cold Bay. Walls are concrete block, except for exterior walls (the south elevation), which are steel. Sets of double steel casement doors separate the main space from the two smaller storage areas. An airlock at the south end of the main space consists of two sets of double steel casement doors at either end of a vestibule, permitting access for trucks to be loaded or unloaded. A 10-ton overhead bridge crane services this area.

Offices

The main office area, southeast of the Cold Bay, is an adaptive reuse of what was originally designed to be the Engine Receiving Room. In a large, high, metal and concrete block-walled envelope are 8 foot high wood-grained pressboard partitions, forming ten office cubicles and an open reception area around a central corridor. Other office work stations, including those for drafting or other special tasks, are located in or around the perimeter of the operating galleries, particularly on the second floor.

Shops

Shops, located adjacent to the Cold Bay, include machine, welding, and electric. The welding shop is in the northwest corner of the Cold Bay and is covered by a metal frame mezzanine with plywood sheathing as flooring material. The south and east sides of the welding shop are canvas. The machine shop, next to the welding shop, is between the Cold Bay and the East Operating Gallery. A metal roll-up door leads into the machine shop from the north exterior of the building. The electric shop is just south and separate of the machine shop and accessed either through standard doors in the southwest corner of the Cold Bay or from the Operating Gallery. These shops were able to perform maintenance and repair on equipment throughout the facility, including the close-circuit TV system, large and small manipulators, cranes and hoists, and the railroad system. Most, if not all of the tools, as well as stockpiles of spare parts, appear to remain in place.

Restrooms

Restrooms are located on all floors. While most are for men, womens' rooms are located in the basement and on the first floor. All restrooms have gray ceramic tile floors in an abstract geometric pattern of 2 and 1 inch square tiles, and 1 by 2 inch rectangular tiles. Wet walls have a gray ceramic tile wainscot to four feet high. Walls are either concrete or concrete block, and ceilings are concrete. Some restrooms also feature showers. The womens' restroom on the first floor, room 10, features an approximately 4 inch thick concrete shield door along its east wall. Another shield door and an emergency shower are next to the womens' restroom on the first floor. This door leads to the Cold Bay.

Shielded Counting Room

The shielded counting room, located between the Cold Bay and the first floor Operating Gallery, is accessed by a long north-south hallway. The room is distinguished by a copper-lined door. No equipment remains in the room.

Mezzanine

The Mezzanine is located between the first and second floors and next to the Cold Bay. It is accessed through a door from the stairway to the second floor. Next to this door in the southern portion of the room is a bank of electric motors. A small, sliding metal door in the north wall opens onto the Cold Bay. This door only provides visual access, however, because it is about 10 feet above the floor of the Cold Bay and no stairs are present. The Mezzanine was used for storage of electrical equipment and documents, including reports and photographs, associated with the construction and operations of the facility.

Facility Support Areas

In a technically-oriented building set in a harsh desert climate, utility systems are of critical importance and much space throughout the building is devoted to them. Facility Support Areas include the boiler room, a compressor room and the HVAC control console in the basement directly below the boiler room, and an electrical equipment room on the second floor. The boiler room contains two large hot water boilers, hot water pumps, and an emergency electric generator. The compressor room houses the air compressors, air conditioning refrigerators, vacuum pumps, and the chilled water distributing pumps. The electric room contains the electrical supply systems for the building, power breakers for all systems supplied by the emergency generator, and power to the perimeter lighting at the Radioactive Materials Storage Facility down the road from the E-MAD facility.

The E-MAD building includes a complex mechanical system designed to filter and vent radioactive particles as well as provide user comfort. The HVAC system is comprised of eleven subsystems. It provides proper heating and cooling, and of utmost concern, filters the air to remove radioactive particulates prior to release in the environment through two exhaust stacks. These stacks are each 114 feet high, with one located at the northwest corner and the other toward the southwest corner of the building. Air exhausted from the Hot Bay and West Process Cell is prefiltered with roughing filters and followed by high-efficiency filters to remove the radioactive particulates. These high-efficiency filters remove 99.97 percent of the particles 0.3 micron or greater in size. In addition, to minimize the spread of airborne radioactive contamination, the HVAC system is designed for separate area pressure controls which produce air flow from cold areas to hot areas. That is, the system maintains a lower air pressure in radioactive areas to prevent accidental spread of contamination to personnel in the Operating Galleries.

Associated Structures

Three primary ancillary buildings are present on the site. The largest, a train shed, 110 feet long by 48 feet wide and 48 feet high, is a gable-roofed corrugated metal building at the northern perimeter near the main entrance gate. This structure is contaminated with radioactive material and sealed, and consequently, was not accessible during the fieldwork. The train shed, situated at the end of a rail spur, is for the maintenance and storage of the railroad system. A 15-ton bridge crane is inside, and supposedly, equipment and parts for the rail cars. These include a 225-ton shielded locomotive with diesel-electric drive, an 80-ton standard locomotive with diesel-electric drive, a 25-ton locomotive with diesel-electric drive, a Fairbanks gas engine rail inspection vehicle, two battery-powered and radio-controlled locomotives, and various test cars, flat cars, dump cars, and nuclear engine handling cars. On the west side of the main E-MAD building are five railroad cars: two flatbed cars, one car that appears to be for cabling or hoisting, and two locomotives. Just southwest of the train shed is the flammable storage shed, a low, partially-bermed and square concrete-block building accessed by a double steel door. The third primary ancillary building is a small, one story, approximately 9 feet long by 7 feet wide and 9 feet high, guardhouse located at the main entrance. This structure is wood frame, flat-roofed, and has windows on all sides.

Two small, square, one-story metal buildings on concrete pads and two plywood "Brock" houses are on the west side of the main E-MAD building. On the east side is a fenced transformer substation, with the capacity to provide 3,750 KVA of electrical power. This area (labeled Station 25-7) features a metal building, approximately 10 feet by 12 feet, on a concrete pad, and a skeletal frame structure with insulators, lights, and electric wires. South of the transformer substation is a metal water tower with a 75,000 gallon capacity. Open storage areas for surplus materials are on the north and south sides of the building, with the south side as the primary storage area.

III. HISTORICAL INFORMATION

The E-MAD is one of seven separate, but interconnected, complexes associated with the Nuclear Rocket Development Station (NRDS) in Area 25 (originally Area 400) of the NTS. The NRDS was constructed to support the Rover program to develop nuclear rocket reactors for use in the space program (Space Nuclear Propulsion Office n.d.). In addition to E-MAD, facilities within the NRDS are two reactor test cells (Test Cells A and C), a reactor assembly and disassembly building (R-MAD), an engine test stand (ETS 1), a control point complex, and a support area. Also associated with this program are the PLUTO facilities in Area 26 (originally Area 401) of the NTS. Project PLUTO was designed to demonstrate the

feasibility of a nuclear ramjet engine for use in strategic missiles (Atomic Energy Commission 1961:157-158).

According to House (1963), the first recorded mention of American nuclear rocket propulsion was in 1944. Personnel from Los Alamos Scientific Laboratory (LASL) speculated on the possibility of nuclear propulsion, whereby nuclear energy, with its tremendous power, could be used in the then developing field of rocketry. It was not until the early 1950s, however, that interest once again turned to the concept of a nuclear-propelled rocket and the Atomic Energy Commission (AEC) instructed LASL and the University of California Radiation Laboratory (UCRL) to research the idea of using nuclear power for rocket propulsion. They were also charged to plan a research center, with the setting aside of land within the NTS for the program.

In 1955, the United States Air Force took interest and entered into a joint program, termed Rover, with the AEC (House 1963:2). The objective of the Rover program was to develop a nuclear rocket engine in which liquid hydrogen was heated and expelled through a jet nozzle to provide the thrust for propulsion of space vehicles (Atomic Energy Commission 1963:109). The mission of the AEC was to develop and test the nuclear reactor, whereas the Air Force was responsible for the development of the non-nuclear systems and components and launch vehicle applications (House 1963:2). In 1957, a specific reactor development approach, using uranium-loaded graphite fuel elements to heat hydrogen, was selected for further advancement, marking the beginning of the Kiwi reactor project managed by LASL. The UCRL was directed to apply their efforts in the development of ramjet applications. In 1958, the program was transferred to the newly formed National Aeronautics and Space Administration (NASA) and eventually evolved into a joint agreement between the AEC and NASA establishing the Space Nuclear Propulsion Office (SNPO) and the NRDS (Miller 1984:1). The program became part of President John F. Kennedy's commitment for United States superiority in space. The NRDS mission was to provide a center for the development of nuclear reactors, engines, and engine stagings for the national space program. Research and development was primarily done by LASL.

This joint agreement marked a turning point in the research as the program finally began to take shape. The R-MAD facility was built in 1958. Between 1959 and 1961, initial testing at R-MAD and associated Test Cells A and C occurred on the Kiwi series of reactors. Two series of Kiwi tests were scheduled for the development phase of the project (House 1963:5). The first series, known as Kiwi-A, included three reactor tests, and involved the development of a fuel element using gaseous hydrogen. The first of these tests was conducted at the NRDS in July of 1959, followed by the second in July of 1960, and the last in October of 1960 (House 1963:6). Subsequent Kiwi-B tests would involve the use of liquid hydrogen rather than gaseous, with the first of three tests conducted in December of 1961, another in

September of 1962, and a third in November of 1962. The reactor core and its support failed during these latter tests, prompting extensive development and testing of the reactor itself before further tests were conducted (House 1963:7). Work continued on this particular program until 1965. The Kiwi-developed graphite reactor technology and design concepts would eventually evolve into the Phoebus project, expected to provide the technology for developing reactors with higher power levels, longer operating times, and increased restart capabilities.

Because the results of the initial Kiwi reactor program were so encouraging, the second phase of the Rover program, named the NERVA (Nuclear Engine for Rocket Vehicle Application) project, was initiated in 1961 and was awarded to the Aerojet-General Corporation. Westinghouse Astronuclear Laboratory was selected as the principal subcontractor for developing the flight reactor and certain other aspects of the nuclear engine development program. Three guidelines were established for the NERVA project (House 1963:8-9). The first was to use the Kiwi technology and configuration, that is, development of the NERVA engine was to be based on the solid core, heat exchanger reactor concept, originally selected by LASL. The second guideline stated that development of non-nuclear components and systems would not occur until a reactor configuration was successfully tested. The third guideline provided as the ultimate goal of the program to demonstrate that a rocket with nuclear propulsion could perform safely in space.

Ground was broken for the construction of the E-MAD complex in August 1962. The Vitro Engineering Company of New York City performed the architectural and engineering design, and the Catalytic Construction Company was the prime contractor. It would take approximately 2.5 years for construction to be completed. Specifically, the facility was designed to assemble, disassemble, and perform post-operational inspections of hot nuclear reactors following tests associated with the Rover project. Construction was completed in 1965, at a cost just over \$50 million (Atomic Energy Commission n.d.). Subsequent proposals to add an office wing east of the Post-mortem cells and a second Hot Bay were never acted upon. An explanation of planned facility operations has been provided by House (1963:14-15):

The reactor and the non-nuclear engine subsystems will be assembled into the complete test engine in the engine maintenance, assembly, and disassembly building (E-MAD) at NRDS. . . When assembled, the engine is placed on the engine installation vehicle for transportation and installation into the test stand, which is located approximately two miles from the E-MAD building. . . The engine installation vehicle (EIV) is essentially a railway flat car with appropriate superstructure to support and transport the engine. The shielded control car houses two men who will have control over the entire engine

transport and test stand installation sequence. Motive power is provided by the prime mover . . . Following the engine tests, the engine is remotely disengaged from the test stand, attached to the EIV, and returned to the E-MAD building, where it is remotely disassembled for post-mortem inspection. . . . The engine is disassembled into its major subsystems in the main bay of the E-MAD building, and small satellite cells located around the periphery of the main bay are used for the disassembly and post-mortem inspection of individual subsystems and components.

The first test of the NERVA rocket reactor was conducted on September 24, 1964 (Space Nuclear Propulsion Office 1964). A second reactor test occurred on October 15, 1964 (Atomic Energy Commission 1965:109-114). Tests of the actual NERVA engines, however, did not take place until 1966 (Atomic Energy Commission 1967:181-193).

Progress continued during 1965 and the year was marked by the successful launch and operation of the first atomic reactor in space and completion of successful ground tests on the Rover rocket reactors. It was believed that the advancing technology developing in regards to the rocket propulsion systems would ultimately enable the United States to undertake long and complex space missions possible only with nuclear energy. On June 21, 1965, the AEC reorganized its space-related research and development activities, and established a Division of Space Nuclear Systems (Atomic Energy Commission 1965:109-114).

A third project, Reactor-In-Flight-Test (RIFT), was to follow the successful testing of NERVA. The objective was to develop a nuclear propellant stage for testing the NERVA engine in space. This program was to have direct application in a SATURN V launching planned for 1970 (Space Nuclear Propulsion Office n.d.). RIFT was to have its own complex at NRDS, including a Stage Assembly and Maintenance (SAM) building, stage test firing positions with a control center, and a demating facility (Space Nuclear Propulsion Office n.d.). Late in 1963, however, revisions in the Rover program placed greater emphasis on ground-based research and engineering, thus deferring the further development of flight systems. RIFT was eventually canceled, and the flight objectives of NERVA were postponed (United States Atomic Energy Commission memorandum from William H. Slaton, Director, Divisions of Plans and Reports, January 3, 1964). It was probably this change in focus that also aborted plans for extending the E-MAD facility as planned. Research on NERVA continued until the entire NRDS program was terminated in 1973 (Miller 1984:5).

Because of the huge hot cell, the Hot Bay, purported to be the largest in the free world, the E-MAD remained fully operational long after other facilities associated with the nuclear rocket program were mothballed. In the late 1970s and early 1980s, the complex was reused

by the Lawrence Livermore National Laboratory (LLNL) for spent nuclear fuel handling and packaging. The program was initiated by a 1977 deferment of commercial reprocessing of spent fuel precipitated by the build-up of spent fuel at nuclear reactor sites. This program sought to test the concept of regionally-sited spent fuel storage installations until reprocessing of the fuel could be performed (Westinghouse Electric Corporation 1981). The program involved receipt of spent fuel assemblies, design and development of sealed canisters for storage demonstration and configuration, performance of fuel calorimetry and canister gas sampling, and design and development of a canister cutter system (Baird 1996). A calorimeter was added to the E-MAD and installed in a pit on the east side of the Hot Bay (United States Department of Energy 1980).

The Climax Spent Fuel Test would involve the storage of eleven canisters of spent fuel from a reactor core for approximately 2.5 years. The spent fuel was sealed into canisters at the E-MAD facility and transported to the Climax Spent Fuel Site in Area 15 of the NTS (Baird 1996). The objective of the test was to evaluate the feasibility of safe, reliable short-term storage of spent fuel at a plausible repository depth in granitic rock. The spent fuel was retrieved and technical data obtained on the fuel. Results of the test indicated that spent fuel could be emplaced, stored, and then retrieved using existing engineering technology (Lawrence Livermore National Laboratories 1984).

The E-MAD facility was considered for another attempt in the mid 1980s for the development of a space nuclear power system. The SP-100 proposal outlined three conceptual designs using a liquid metal cooled fast reactor. The complete SP-100 space power system employs a liquid metal cooled nuclear reactor and either a static or a dynamic power conversion system to produce 100 kilowatts of electric power. Testing of the reactor and control systems was proposed to be conducted at the E-MAD facility (United States Department of Energy 1985).

The E-MAD along with the entire NRDS complex would be completely closed in the 1990s due to funding restrictions and the Department of Energy's focus on nuclear weapons testing. All of the various NRDS facilities were left intact in the event that the facilities would once again be used for research, development, testing, or storage.

IV. SOURCES

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V. PROJECT INFORMATION

This documentation has been prepared at the request of the Department of Energy, Nevada Operations Office in response to the management of cultural resources on the Nevada Test Site. Key components in the operation of the E-MAD facility, i.e., manipulator arms, are to be removed by Sandia National Laboratory and transferred to a facility in Albuquerque, New Mexico. The arms will be employed in a new program by the Department of Energy for the production of Molybdenum-99, which decays to Technetium-99m, an isotope used for radiopharmacy diagnostic tests in hospitals.

Project Manager and Principal Investigator for the recordation of the E-MAD facility was Colleen M. Beck of the Desert Research Institute, Las Vegas, Nevada. Nancy Goldenberg of Carey & Company, Inc., San Francisco, California was the historic architect for the project. The photographer was Richard Smith of Bechtel Nevada. Other personnel in the recordation and document preparation included Harold Drollinger, Robert Jones, Jeff Wedding, and Diane Winslow of the Desert Research Institute and Keith Kolb of Bechtel Nevada. The documentation is based on a previous investigation conducted by Desert Research Institute, reported in *A Historical Evaluation of the Engine Maintenance Assembly and Disassembly Facility, Area 25, Nevada Test Site, Nye County, Nevada*, 1996.

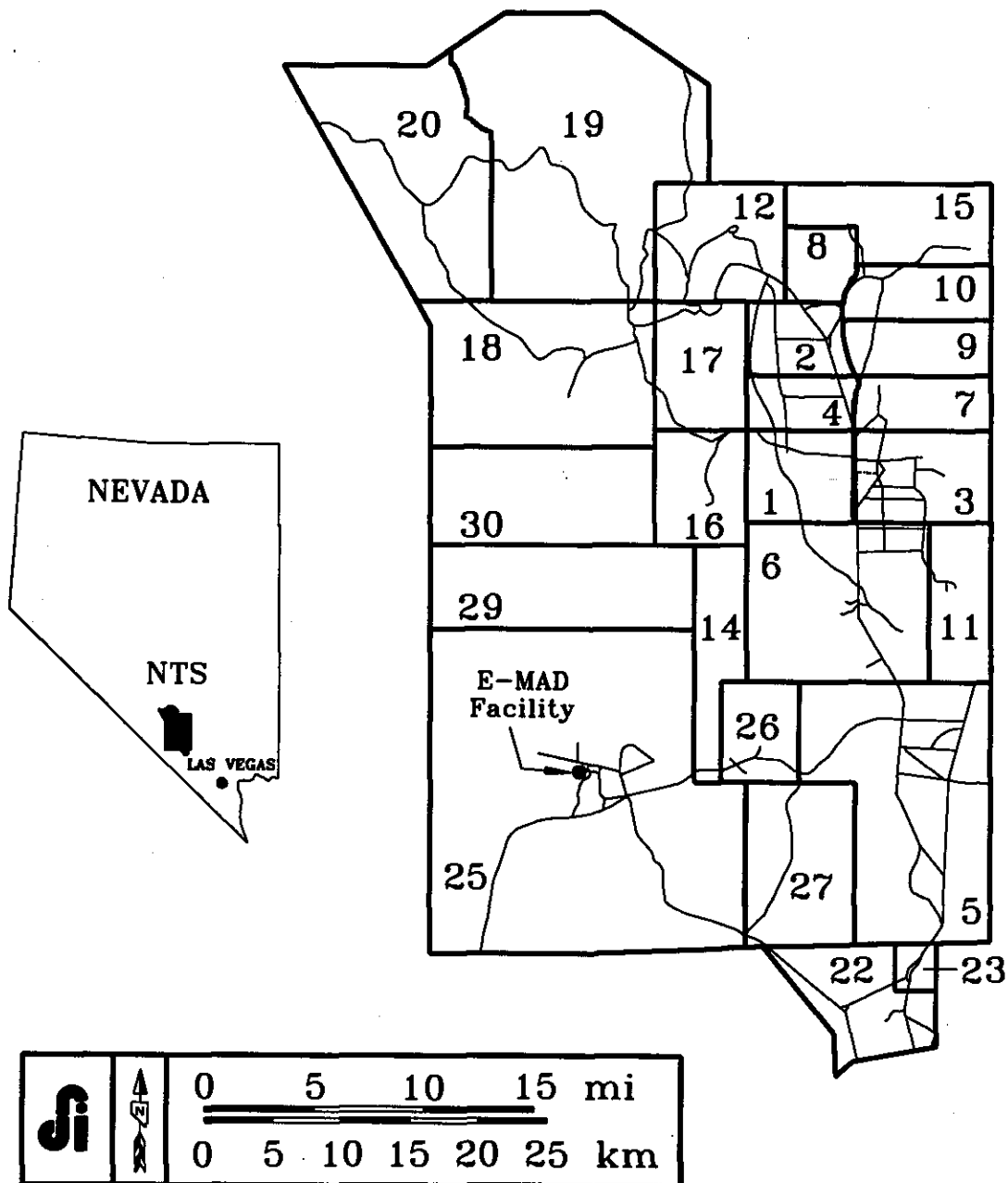


Figure 1. General location of the E-MAD facility on the NTS.

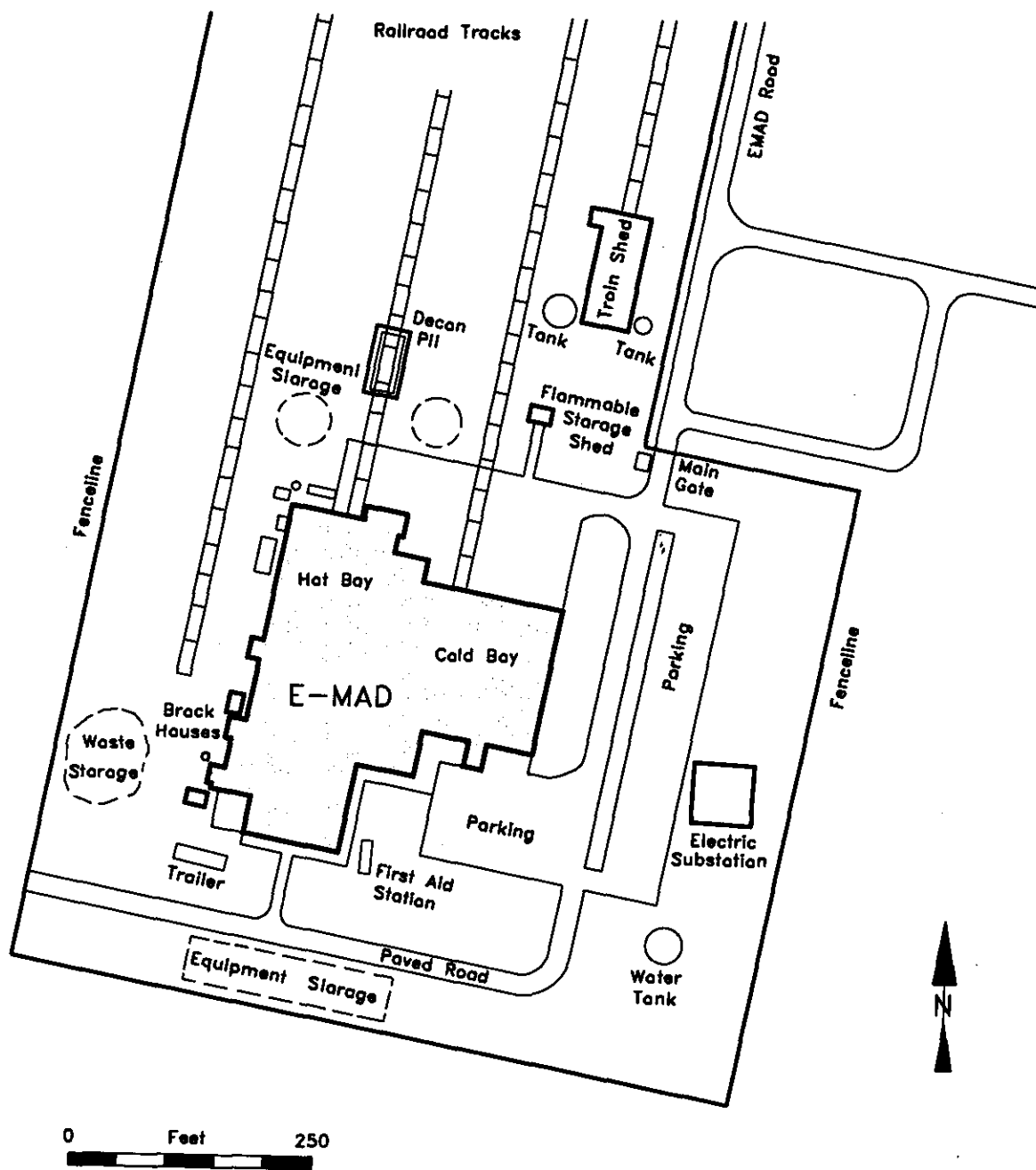


Figure 2. Site map for the E-MAD facility.

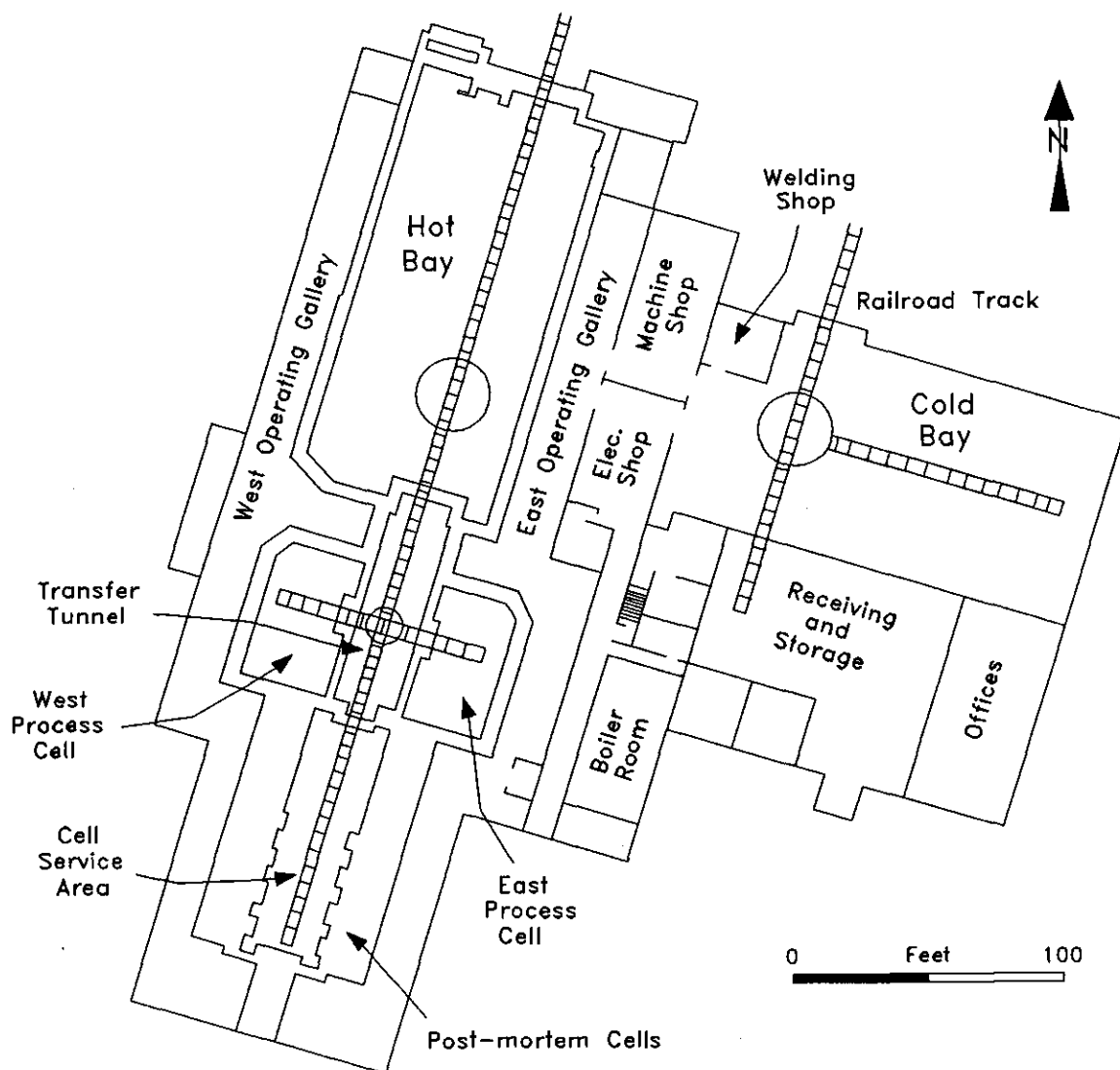


Figure 3. First floor plan for the main E-MAD building.

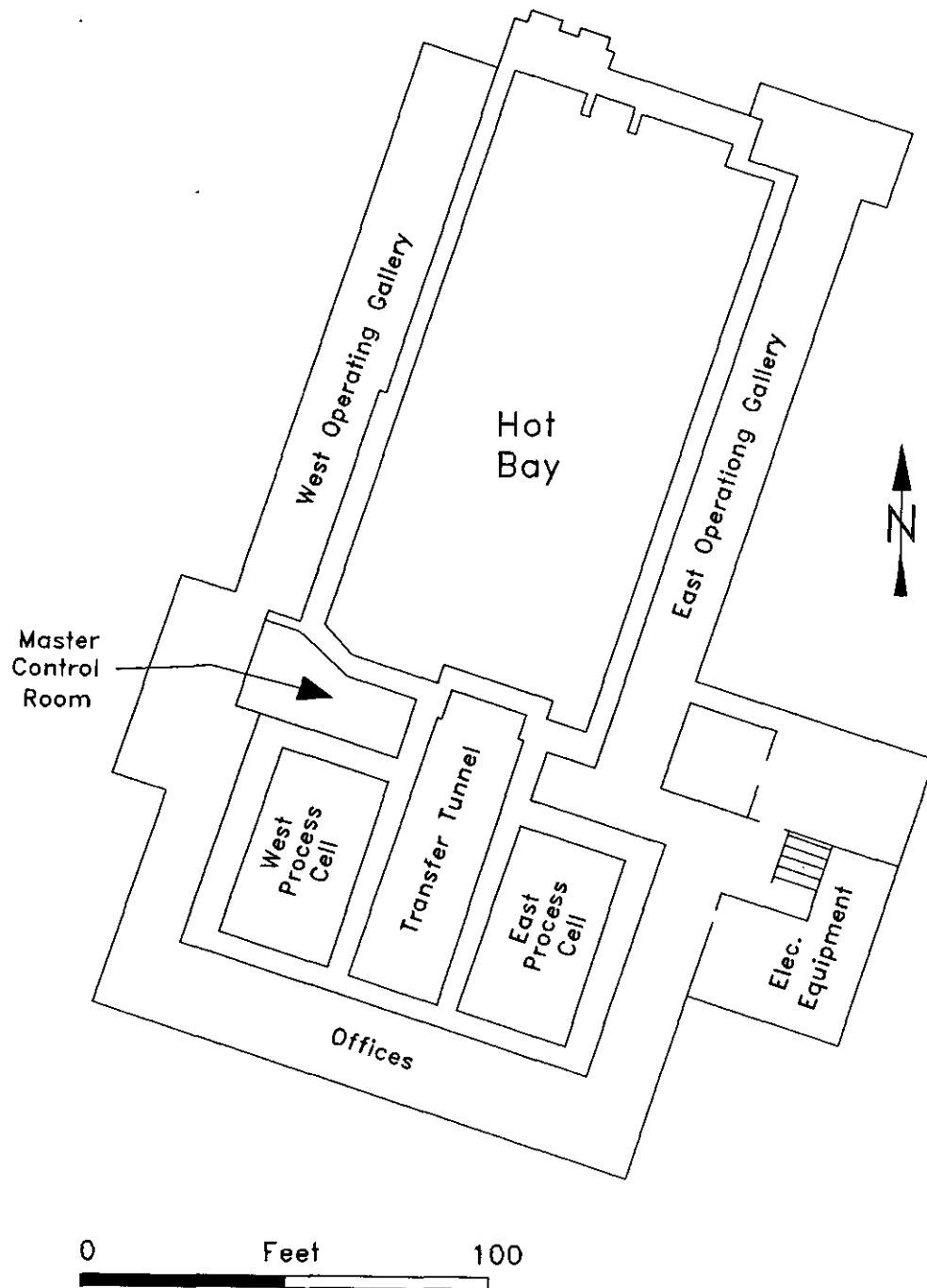


Figure 4. Second floor plan for the main E-MAD building.

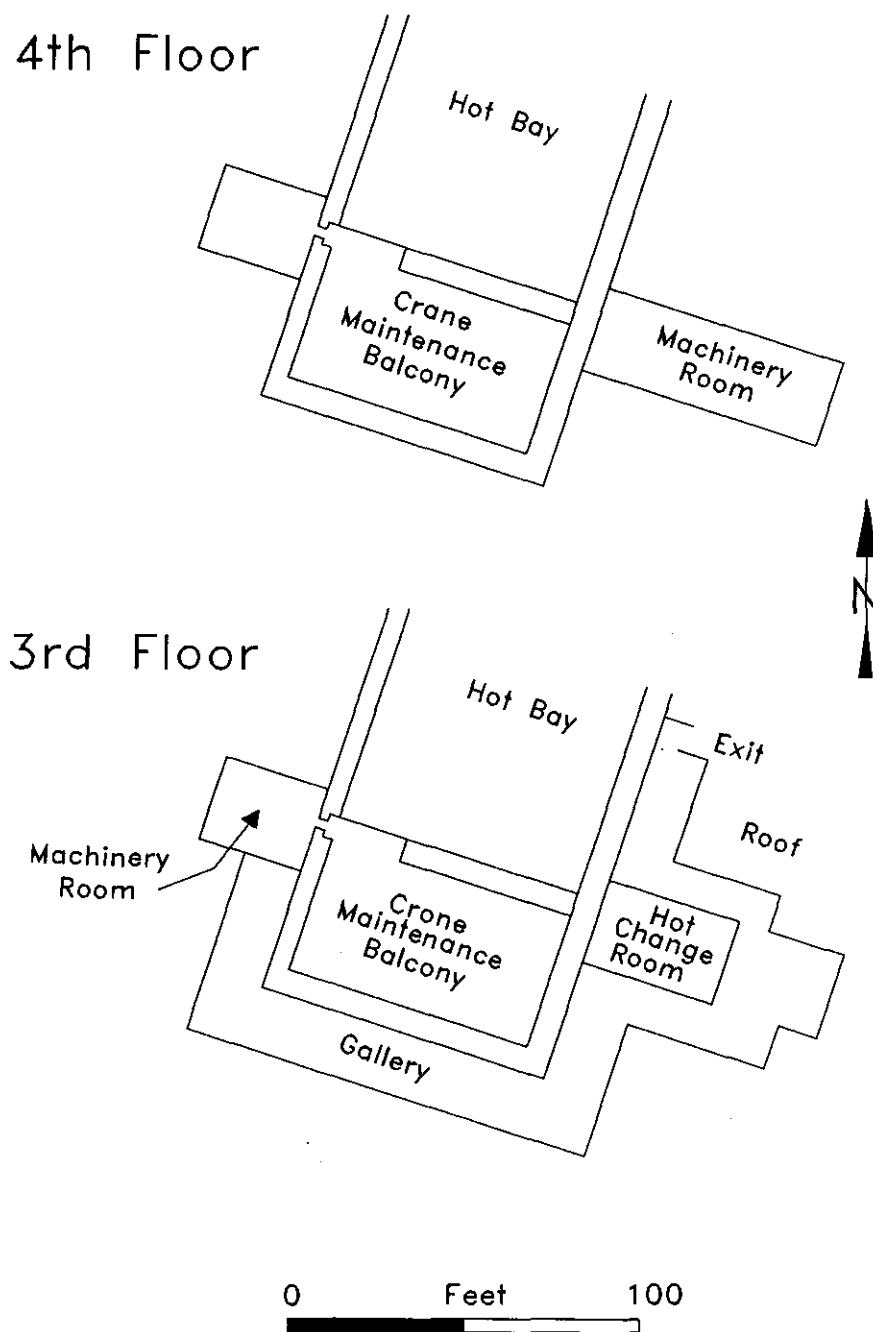


Figure 5. Third and fourth floor plans for the main E-MAD building.